

Scope of Work: Fourth Assessment of Climate Impacts on California

Introduction

The State of California has generated three scientific climate assessments since 2006. These reports have been instrumental in guiding state policy and supporting informed responses to climate change. The Fourth Assessment will continue to advance the science that supports sound policy while responding directly to state, regional, and local decision-makers who need information to guide planning. The Fourth Assessment will allocate \$2.5 million each year for the next two years to selected research projects, and these research projects will be defined in 2014, with results expected in 2017 or 2018.

The upcoming report will comprise an integrated portfolio of studies, including a suite of studies dedicated to the energy system as well as a comprehensive, multi-sectoral analysis addressing extreme events, local impacts, and response options to protect economic interests as well as natural resources. To further enhance the scope and policy impact of the Assessment, as well as contend with a constrained funding environment for State-sponsored research, the Assessment will coordinate with federal, local, and regional efforts and may seek funding from foundations and NGO's.

Building upon the research of the previous assessments, the Fourth California Climate Change Assessment (Fourth Assessment) will provide critical additional information to support decisions that will safeguard the people, economy and resources of California. Among other informational gaps about climate vulnerabilities, California still lacks critical information regarding expected climate impacts from extreme weather events. This is essential because climate change not only creates new average conditions, but is also expected to create more extreme events such as more frequent and more severe wildfires, and more intense and more frequent drought. A recent study by the U.S. Geological Survey shows that a single extreme winter storm in California could cost on the order of \$725 billion – with total direct property losses of nearly \$400 billion, of which \$20 billion to \$30 billion would be recoverable through insurance, and business interruption costs of \$325 billion.

The Fourth Assessment will help California to better understand the scope, timing, cost, and feasibility of various management options to address climate risks. For example, studies are needed to understand the infrastructure and capital needed to relocate and/or shifts crops to support agricultural production under a changing climate. Accurately understanding climate risks and management options will allow the state to prioritize actions and investments to safeguard the people, economy and natural resources of California.

The Fourth Assessment will explore and identify the interconnected aspects of research, strategic planning efforts, and action. These three complementary pieces of work are needed to safeguard the people, economy, infrastructure and natural resources of the state from increasing climate threats. The Fourth Assessment is designed to meet the climate research needs of state agencies, but also regional and local partners working on climate change issues. The scope of research will also be publicly vetted with stakeholders, local governments, and other.

A Brief History of California Climate Assessments

The first California climate change assessment (First Assessment), completed in 2006, began the work of trying to “downscale” global climate models to provide information about expected climate impacts at a

regionally-relevant scale. Climate impacts will not be uniform across the globe, and it is necessary to have climate impact information at a finer resolution (i.e. the western United States, the state of California, sub-regions and communities in California) in order to craft local, state and regional climate policies and solutions. The First Assessment provided critical support for the passage of California's Global Warming Solutions Act (AB 32) and the development of the Air Resources Board's (ARB) 2008 Scoping Plan for reducing greenhouse gas emissions.

The second California climate change assessment (Second Assessment), completed in 2009, provided initial estimates of some of the economic impacts of expected and unfolding climate risks in the state, such as costs to coastal economies from sea level rise. Expected climate impacts will have very significant economic impacts that may be reduced with appropriate measures to reduce climate risks. The Second Assessment provided support for the state's 2009 California Climate Change Adaptation Strategy, the state's first multi-sectoral effort to plan for climate risks.

The third California climate change assessment (Third Assessment), completed in 2012, was shaped by requests for additional information regarding state vulnerabilities to climate change, including: 1) the need to better understand institutional barriers to efforts to prepare for climate risks, 2) risks in specific sectors (water, energy, agriculture), and 3) risks at the local scale. The Third Assessment supported the development of the Safeguarding California Plan for reducing climate risk (an update to the 2009 California Climate Change Adaptation Strategy). The significant advances in climate science in the Third Assessment allowed the Safeguarding California Plan to expand and refine recommendations for reducing climate risk in California.

Climate science and knowledge about climate impacts continues to evolve and be refined, both through improvements in impact modeling and direct observations of the changing climate over time. In order to support California leadership on climate policies and actions, it is critical that California continue to invest in regionally-relevant climate science that is complementary to local, federal and international climate science efforts.

Each of the prior three assessments was developed under the leadership of the California Energy Commission (CEC), with advisory support from a steering committee of state agencies. The development of the Fourth Assessment will be coordinated under the leadership of the California Natural Resources Agency (CNRA), with the Research Working Group of the Climate Action Team serving as an advisory steering committee.

Developing the Scope of Work for the Fourth Assessment

The Fourth Assessment builds on California's pattern of in-depth looks at the impacts of climate change on the state. Through its structure and approach, the Fourth Assessment presents a unique opportunity to investigate cross-cutting issues in a holistic manner, considering impacts and policies across sectoral boundaries. This draft Scope of Work was developed through the solicitation of research concepts from state agencies, compilation and review by a staff working group, and review by the Climate Action Team Research Working Group (the Research CAT). The review and compilation of the research concepts was based on a set of priorities and criteria developed through several recent state-led climate policy efforts, including the development of Safeguarding California, which is the state's climate adaptation plan; the update to the AB 32 Scoping Plan, which outlines strategies to reduce greenhouse gas emissions; and the forthcoming Climate Change Research Plan.

California state agencies, led by the Research CAT, recently completed a public review draft of the Climate Change Research Plan. The Plan outlines research needs across sectors, with a focus on near-term research needs (i.e., in the next five years). The Research Plan is grounded in the research and policy needs outlined in the AB 32 Scoping Plan, Safeguarding California, and other climate policy documents (e.g., CDFA Specialty Crop Report, CDPH's Extreme Heat Guidance, etc.), and is intended to leverage past and existing climate change research. The Research Plan outlines research needs by sector, but also highlights several cross-cutting priority needs for the state's climate research activities.

The most pressing cross-cutting needs are:

- Understanding climate risks – projected climate impacts and monitoring changes
- Socio-economic impacts of climate change and policy responses
- Strategies needed to prepare for climate impacts
- Integrating climate mitigation and adaptation

The Fourth Assessment provides the first opportunity to address these cross-cutting elements of the Climate Change Research Plan with Tier 1 proposals addressing Agriculture, Water, Forests, Public Health, Biodiversity, Emergency Management, Oceans, and Transportation. Research funded through the Fourth Assessment can examine issues at a statewide scale or in specific regional contexts. Preference might be given for regionally-focused studies that will provide transferable or generalizable findings, though there could be instances where this is not the case.

Concurrent with the Fourth Assessment research being led by CNRA, the CEC will be investing in research on climate change impacts to the energy sector under the Public Interest Energy Research-Natural Gas (PIER-NG) and the Electric Program Investment Charge (EPIC) programs. This effort proposes to produce practical information on greenhouse gas emissions, mitigation, impacts, and adaptation with a primary focus on the service territories of the investor-owned utilities. Over the next three years, the potential areas for research include developing probabilistic climate change scenarios for California's electricity sector, potential impacts of climate change to renewable sources of energy, long-term evolution of the electricity system under climate change impacts, barriers to adaptation to the electricity system, seasonal and decadal probabilistic forecasts for the electricity system, and measuring adaptation progress and effectiveness. The CEC will also continue research on specific technologies and systems that will help provide resiliency in light of climate change impacts. The CEC's research goals under the EPIC program are described at greater length in its Proposed 2015-2017 Triennial Investment Plan. Implementation of these research priorities will be publicly vetted in a parallel process to this Scope of Work, and funds will be allocated through a competitive process.

These two research tracks by the CNRA and the CEC will be coordinated and integrated to the extent feasible to take advantage of common scenario development and research synergies and to avoid redundancy in the funded research.

Developing Research Priorities for California's Fourth Assessment

The Assessment process provides an opportunity to research climate impacts and policy responses, working across sectors and scales. With a limited amount of funding available, the Fourth Assessment looks to leverage complementary research that is underway or planned and to capitalize on partnerships with research institutions. Through these efforts, the Fourth Assessment seeks to broaden the reach and impact the state's research investment to better serve state, regional, and local entities working to address climate change.

The research questions addressed in the research concepts submitted fall into two broad areas:

1. Studies that improve our understanding of the impacts of climate change on California’s people, natural resources, and infrastructure;
2. Studies that improve understanding of the scope, timing, cost, and feasibility of management options to address climate risk and reduce GHG emissions;

Perhaps more critically, given limited funds available, the research concepts need to be evaluated against a set of criteria. The following criteria have been applied to help assess the research concepts:

- Research opportunities that invest in cross-cutting research areas to address issues and inform actions across multiple sectors;
- Research that Improves understanding of actions that Integrate climate change mitigation and adaptation actions and the relationship between them;
- Opportunities to leverage complimentary research efforts

Recognizing that all concepts submitted provide valuable information to state agencies, the staff group has identified research projects that currently address state agency research needs. Funding for the Fourth Assessment will be \$5 million split over 2 years. To address this we have separated the Tier 1 proposals into Round 1 and Round 2, which will be funded in sequence as required by the Legislature. Research concepts were then grouped within each of these tiers to integrate across sectors and define broader research areas. Topics included in Tier 2 are important areas of research, but that we would only be able to pursue by leveraging outside funding and research partnerships.

- **Tier 1:** Priority research areas to be funded through available state funds
 - o **Round 1**
 - **Agriculture, Forests, Public Health, Water**
 - o **Round 2**
 - **Biodiversity, Emergency Management, Oceans, Transportation**
- **Tier 2:** Important research areas to be pursued through partnerships and opportunities to access additional funding and support

Tier 1: Priority Research Areas

Below are five priority research areas for the Fourth Assessment. The topics are broadly defined and raise questions across sectors and scales. Research to address these questions can take place at different scales and in different regions. Numerous topics connect these five research areas and a guiding goal for the Fourth Assessment will be to make these connections both as the work is underway, to the extent possible, and in the final presentation of the findings. The goal of the work is to build a set of practical and meaningful information to help California achieve its climate policy goals at the state, regional, and local levels.

Research Area 1: Climate Change and Agricultural Lands, Working Landscapes, Forests, and Oceans

The Fourth Assessment seeks to better understand the impacts of climate change on agricultural lands, forests, working landscapes, and coastal resources in California, strategies to respond to these risks, and impacts on resources, public health, and ecosystem services.

Specific research questions include the following:

- How will a changing climate affect shifts in vegetation, impacts on crops, impact on carbon sequestration, wildfire regimes?
- What crop practices are most resilient in the face of a changing climate?
- What critical habitat linkages and refugia are needed to increase species survival rates under a changing climate?
- How do different forest management practices affect forest carbon sequestration?
- How to forest management practices affect wildfire risk? What are the implications for public health?
- How do land management practices affect carbon storage and sequestration in working landscapes?
- How will ocean acidification and hypoxia stress California's ocean ecosystems? What can be done to boost resilience in the face of these threats?

Research Area 2: Economic Approaches to Boosting Resilience

Through this work, the Fourth Assessment seeks to better understand the role of economic tools to increase resilience in the face of climate risks. Areas of interest include the insurance industry and market-based tools to increase conservation and efficiency.

Specific research questions include:

- How and when climate change will affect insurance rates through, for example, impacts on wildfires?
- What market-based tools are available and what is their potential to reduce agricultural water usage?
- What financing tools are available to fund adaptation activities? Under what conditions should different tools be employed?

Research Area 3: Planning for a Changing Climate

Cities, counties, and regions are critical decision makers when it comes to planning for a changing climate. Land use planning, transportation investment, and other local planning efforts will shape how communities and infrastructure develop over the coming decades. Through the Fourth Assessment, we aim to examine these topics. In addition, all information and data produced through the Fourth Assessment will be compatible with state planning tools, including Cal-Adapt and the State GeoPortal.

Specific research questions include:

- What are impacts of climate change on active transportation and public transportation systems?
- How can active transportation and public transportation investments be made to maximize climate change benefits – both in reducing GHG emissions and boosting community resilience?
- How can land use planning more effectively integrate climate change considerations?

Research Area 4: Integrated Assessment of Coastal Risks

California's coastal resources are at risk from changing ocean chemistry and rising sea levels. Through the Fourth Assessment, we would like to develop a better understanding of the integrated risk to coastal zones due to flooding, inundation, and erosion under a changing climate.

Specific research questions include:

- Development of improved methods for estimating erosion rates
- What are the integrated risks to specific coastal zone regions as a result of flooding, inundation and erosion from sea-level rise, coastal storms and shoreline change?
- How should risk from sea level rise be incorporated into state planning?

Research Area 5: Water

Climate change will have major impacts on the state’s water supply. As in previous assessments, the Fourth Assessment will examine these impacts and look in more detail at options to prepare for these impacts.

Specific research questions include:

- How could market-based approaches affect water use practices in the agriculture sector?
- What impact will climate change and SLR have on water treatment facilities on our water supply?
- How will climate change stress groundwater supply (and water quality), given diminished water supplies elsewhere and the need for new management schemes for managing groundwater resources?

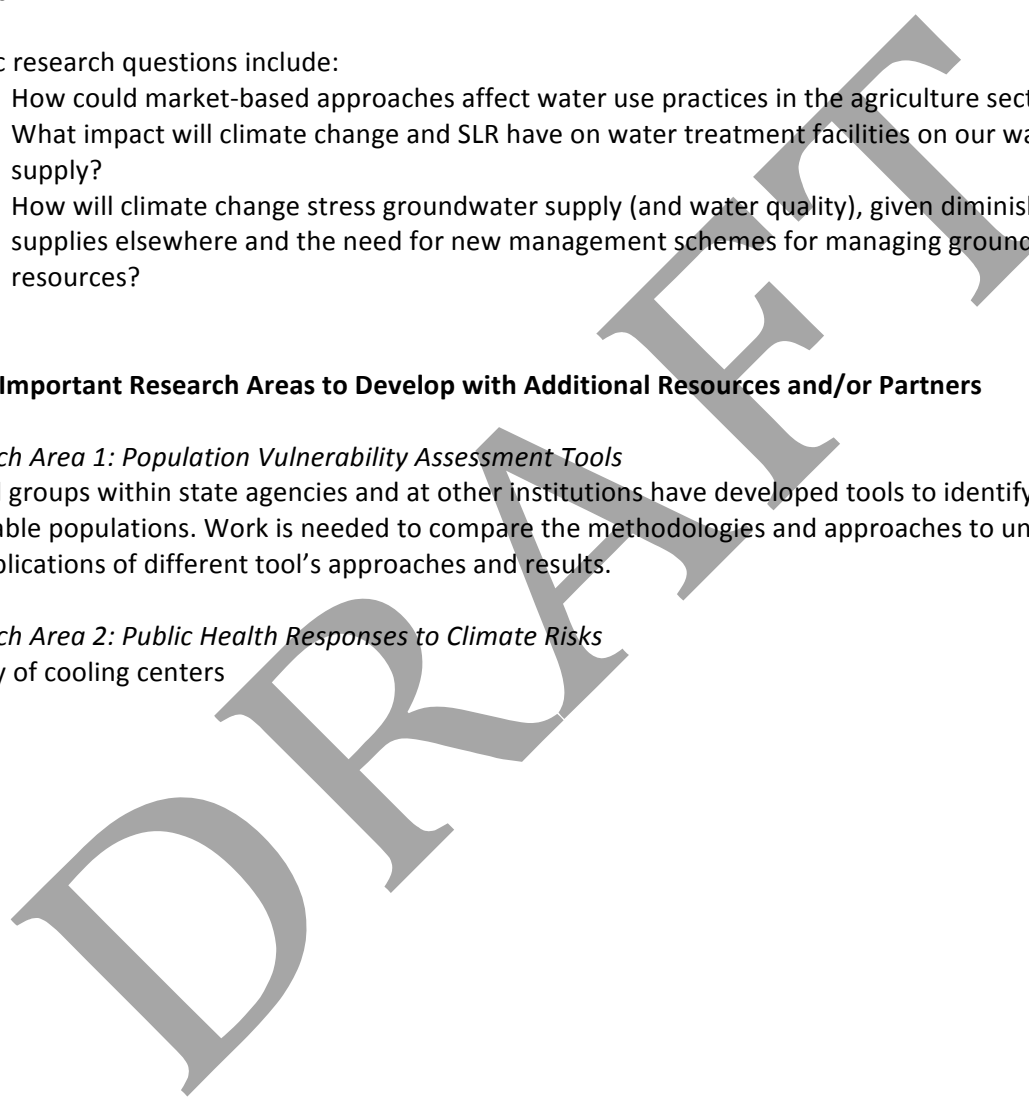
Tier 2: Important Research Areas to Develop with Additional Resources and/or Partners

Research Area 1: Population Vulnerability Assessment Tools

Several groups within state agencies and at other institutions have developed tools to identify vulnerable populations. Work is needed to compare the methodologies and approaches to understand the implications of different tool’s approaches and results.

Research Area 2: Public Health Responses to Climate Risks

Efficacy of cooling centers



Tier 1, Round 1

Requesting Agency	Summary of the problem to be addressed	Amount Request
Cal Fire	The funding request is a rough estimate based on previous work done to estimate changes in vegetation distribution due to climate change using the BIOMOVE model.	\$75,000
Cal Fire	The effects of forest management actions such as fuel treatments on forest carbon pools and avoided greenhouse gas emissions from wildfire is not well known. The science of predicting the effects of fuel treatments on forest carbon balances is unsettled, yet fuel treatments are increasingly being marketed and implemented in part to achieve increased carbon sequestration in forests and avoidance of greenhouse gas emissions from wildfire.	\$200,000
California Department of Food and Agriculture	Climate change effects that are expected to impact California agriculture include decreased yields from increased temperatures, flooding, more intense droughts, increased pests and reduced pollination services. Adaptation to climate change impacts is critical to ensuring the sustainability of California agriculture into the future (Safeguarding California Report, 2014). There is a lack of any information on the economic and environmental costs, benefits and risks of crop relocation in California as an adaptation strategy. This and several related research needs are identified in a recent report based on grower feedback (CDFA, 2013). Filling these research gaps are critical to identifying effective short and long terms strategies for California agricultural adaptation.	\$215,000
California Department of Food and Agriculture	The National Oceanic Atmospheric Administration (NOAA) generates short- and long-term weather forecasts for the United States, but these products are not fully utilized by the agricultural sector. One of the primary reasons is because the NOAA data has not been tailored for the use by growers. The Consortium identified that weather forecasting data for growers to adapt to climate change must include important crop dependent parameters such as evapotranspiration rate, fog presence, soil moisture and winter chill hours with adequate regional spatial resolution. Additionally, national level forecasts include systematic errors for local regions that can be minimized with statistical correction procedures.	\$300,000
California Department of Insurance	Communities rely on affordable and available property and casualty insurance to rebuild and re-establish themselves after catastrophes. There is little information available to understand when and where it is likely that climate change will cause fire/homeowners insurance rates to significantly increase or when the risk of fire may be too great for insurers to assume.	200,000 - 500,000
California Department of Public Health	The State of California has invested in the development of several different tools to quantify and geographically identify vulnerable populations. The development of these tools has not been coordinated and may produce results that substantially differ.	\$50,000

Tier 1, Round 1

California Department of Public Health	Substantial increases in wildfire risk are predicted for California. Wildfire plumes threaten both local communities and the regional transport of combustion products interact with air sheds in major population centers in California. Research is needed to predict ambient air levels to fine particulates (PM2.5) due to regional transport and its impacts on health under future climate change scenarios.	\$200,000
Conservation/Natural Resources	Conversion of agricultural land to other developed uses has been shown to increase GHG emissions by up to seventy times, compared to current emissions. For rangeland, conversion to urban uses is calculated to result in GHG emissions up to 217 times, compared to current emissions. Conversely, conversion of cultivated agricultural land to grazing land will result in an immediate, significant, permanent decrease in GHG emissions by a factor of about 66% per acre fallowed (Jackson, L., et al. 2012).	\$360,000
Department of Parks and Recreation	Historic forest management practices—including a century of aggressive fire suppression—have resulted in forests that are excessively dense with undergrowth and small diameter trees. This buildup of highly flammable biomass is making California’s forests and communities particularly vulnerable to catastrophic wildfires. Recent research indicates that wildfires may be contributing to California forests becoming a source of greenhouse gases rather than a sink.	\$120,000
Department of Parks and Recreation	Future wildfire patterns are likely to present ecological, social, and financial challenges. Projections indicate that the area burned by wildfire will increase with climate change, largely due to changes in precipitation and water demand by vegetation. Wildfires and climate change are both causes of 'type conversion' -- and are likely to exacerbate forestland retraction, reducing tree cover and forestland.	\$158,000
Department of Resources, Recycling and Recovery (CalRecycle)	Water conservation and water use efficiency are key measures in the State's Climate Adaptation plan, and anecdotal data shows that the use of compost and mulches made from recycled organic materials can help California adapt to both drought and deluge. Due to the complexities of soil types, application conditions, growing seasons, and climate, there is a need for additional research that incorporates these complexities and provides quantifiable data for water savings and water quality improvements attributable to the widespread use of these products.	\$400,000
State Water Resources Control Board	California’s agriculture sector uses approximately 80% of developed water in the state and is particularly vulnerable to droughts and the decline in the Sierra snowpack driven by climate change. Much of the existing research on agricultural water use has focused on increasing irrigation efficiency, and has avoided assessing how to reduce total use volume in response to climate change. This project would look at policy and market-based approaches to reduce total agricultural water use by 2050 in a way that would minimize net economic impact while reducing risks of catastrophic environmental and public health impacts from severe drought and a reduction in permanent snowpack	\$50,000

Tier 1, Round 1

State Water Resources Control Board	Rising seas and increased runoff may release partially-treated or raw sewage into streets, buildings, local streams, and coastal estuaries. These releases would directly and indirectly affect water-related industries, habitat, trails, beaches, and parks along the coast. Additionally, impaired water quality, combined with warmer temperatures, could result in algal blooms and increase the spread of water-borne disease vectors.	\$250,000
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Tier 1, Round 2

Requesting Agency	Summary of the problem to be addressed	Amount Request
California Coastal Commission	Methods for estimating change in erosion rates and shoreline change due to future sealevel rise. There is a need for a peer-reviewed methodology for estimating change in erosion rates due to sea-level rise (SLR) for bluffs, beaches, and other shorelines exposed to erosion.	\$300,000
California Department of Fish and Wildlife (CDFW)	As the climate changes, species are expected to move across the landscape in response to changing environmental conditions. Identifying and protecting critical habitat linkages (or corridors) is an important management strategy to increase the likelihood of species survival and reduce overall climate risks to California biodiversity.	\$250,000
California Ocean Protection Council/California Natural Resources Agency	Ocean acidification and hypoxia, two phenomena often coupled for a variety of biological and oceanographic reasons, have the potential for profound impacts on California's living marine resources. California's investment in a network of marine protected areas (MPAs) provides opportunities to study the early impacts of ocean acidification, hypoxia and other stressors, while bolstering the resilience of California's ocean ecosystems in the face of these emerging threats.	\$47,500
Conservation/Natural Resources	Carbon sequestration in rangeland results primarily from forage vegetation growth and are sensitive to precipitation, with higher precipitation leading to greater soil moisture, increased plant growth, and increased levels of soil carbon. California precipitation is temporally and spatially highly variable, with modeled future scenarios showing a likelihood of increased variability. This underscores the need for more complete and ongoing assessment of statewide potential for enhanced management of rangelands for increased sequestration of atmospheric CO ₂ , where feasible.	\$280,000
Department of Parks and Recreation	Conserving biodiversity during climate change will require identifying regions that will provide refugia on a variety of scales: the species scale, ecosystem scale, and landscape scale. A complementary approach is to identify regions that will have relatively stable environmental conditions even as the climate changes. It may be useful for researchers to first identify sources of vulnerability for California ecosystems and then to identify refugia.	\$80,000
Department of Parks and Recreation	State agencies have been directed through Executive Order S-13-08 to consider Mean Sea Level Rise (MSLR) while assessing the vulnerability of projects, reduce risks, and increase resilience. In addition to more strategic project planning, it will likely be necessary to implement proactive, larger-scale actions that address sea-level rise and associated coastal erosion for larger sections of the coast. State agencies need to review and analyze methods for reducing impacts of MSLR beyond shoreline hardening and implement them on a larger scale.	\$150,000
Department of Transportation	Improved traffic management and operational improvements as well as improvements to the condition of the existing pavement surfaces can contribute to a reduction of GHG emissions, reduce delay and improve safety. Research is needed to further understand and implement these traffic management and operational improvement strategies.	\$300,000

Tier 1, Round 2

Governor's Office of Planning and Research/California State Transportation Agency	Climate change and extreme weather pose significant risks to the integrity of transportation systems, including roads, pedestrian infrastructure, and public transportation networks. Caltrans is undertaking work to understand these risks to California's transportation network.	TBD
Office of Emergency Services (Cal OES)	There is a critical need to conduct a statewide risk assessment of existing state owned/operated structures critical to response and recovery operations that are currently located in areas of high hazard risk and subject to impacts of climate change.	TBD
State Coastal Conservancy	Provide information on integrated flooding, inundation and erosion from sea-level rise, coastal storms and shoreline change to support coastal hazard and sea-level rise vulnerability assessments in the Southern California area (Point Conception to the U.S.-Mexico border, including the Channel Islands, harbors, and coastal embayments).	\$500,000

Tier 2

Requesting Agency	Summary of the problem to be addressed	Amount Request
Air Resources Board/Cal/EPA	Data and information is needed to help support the integration of adaptation planning into regional and local land use, transportation, and climate action planning processes.	\$200,000
California Coastal Commission	Current guidance on sea level projections adjusts for large-scale vertical land motion north and south of Cape Mendocino. These adjustments do not properly address locations that are moving differently from the region, such as Humboldt Bay. A peer-reviewed methodology is needed to determine accurate information and inform estimates of Sea Level Rise.	\$500,000
California Department of Public Health	Air conditioning or cooling is the principal strategy for protecting the population during excessive heat days. A substantial segment of the California population, disproportionately represented by vulnerable subgroups, lacks access to air conditioning. Prior research suggests that cooling centers established during heat emergencies are not effectively utilized by vulnerable populations.	\$375,000